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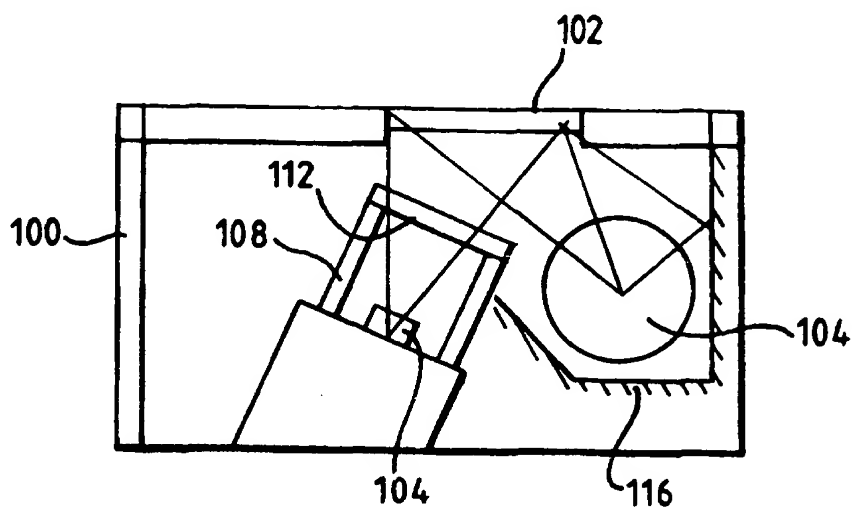


**(57) Abstract**

Detecting counterfeit bank notes is achieved by directing ultraviolet light at a sample from a source (2) and measuring the level of ultraviolet light reflected from the sample using a first photocell (104) and the amount of fluorescent light generated by the sample using a second photocell (106). The detected levels are compared with reference levels and only if both reflective and fluorescent criteria are satisfied is the note declared genuine. The sample, during test, is supported on a glass plate (102). The apparatus uses the value of the intensity of light reflected from the glass plate (in the absence of a sample) as a basis for producing at least one reference level against which a subsequent comparison can be made.

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DETECTION OF COUNTERFEIT OBJECTS

This invention relates to the detection of counterfeit objects. In particular, it relates to the detection of counterfeit objects by detecting unauthorised material of which the object is made or on which it is printed or otherwise formed.

The production of counterfeit objects, in particular, counterfeit bank notes is continually increasing on the back of continuing improvements in printing technology, particularly colour printing. Counterfeit notes are now being made which appear, to the unaided eye, virtually indistinguishable from a genuine note.

Genuine monetary notes are now generally made to a specific formulation such as security or unbleached paper. Counterfeit notes, on the other hand, are generally but not always made from bleached paper. It is known to differentiate bleached from unbleached paper by viewing the paper under a source of ultraviolet radiation, such as an ultraviolet (UV) lamp which emits light having a wavelength which peaks in band of from 300 to 400 nm.

Bleached paper includes chemical components which fluoresce when exposed to ultraviolet radiation, that is, the molecules in the composition of the paper are excited and emit light at a longer wavelength which peaks in the band of from 400 to 500 nm. Because wavelengths of 300 to 400 nm generally lie outside the spectral region of the human eye and because wavelengths of from 400 to 500 nm lie within the spectral region, the phenomena of fluorescence allows some counterfeits to be detected with the human eye.

This process can be automated with the use of electronics by providing a sensor and a comparator which compares the intensity of the fluorescent light sensed with a reference level so as to provide an indication as

to whether the paper is a likely counterfeit or not. Such an apparatus is disclosed in US Patent No. 4.558.224. However, some genuine money notes if washed acquire a deposit of chemicals which fluoresce and some counterfeit notes are made with paper containing little or no fluorescent materials and so the fluorescing phenomenon is not always an infallible way of deciding whether a note is counterfeit or not.

It is an object of this invention to provide an improved method and apparatus of detecting counterfeit objects.

According to the present invention there is provided apparatus for detecting counterfeit objects comprising means for illuminating the object with light within a first wavelength band, a detector for detecting light from said object having a first wavelength within said first wavelength band and a second wavelength within a second wavelength band different from said first wavelength band and said second wavelength band including wavelengths at which counterfeit objects may fluoresce when exposed to light in said first wavelength band, comparison means for comparing the output of the detector with at least one reference level and decision means for deciding, based on said comparison whether said object is counterfeit or not and providing an appropriate indication.

Counterfeit detection apparatus embodying the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a plan view of a first embodiment of the apparatus;

Figure 2 is a section taken on line 2-2 of Figure 1;

Figure 3 is a section taken on line 3-3 of

Figure 1;

Figure 4 is a block diagram of the processor of the apparatus of Figure 1;

Figure 5 is a block diagram of a second embodiment of a counterfeit detection apparatus;

Figure 6 shows a perspective view of a hand-held scanning unit housing the apparatus of Figure 5;

Figure 7 is a side view of the hand-held unit;

Figure 8 shows a front view of the hand-held unit;

Figure 9 is a perspective view of another form of hand-held unit; and

Figure 10 is an under plan view of the unit of Figure 9.

It has been discovered that genuine and counterfeit bank notes often have different reflectivities particularly when exposed to ultraviolet radiation in the band of from 300 to 400 nm. Thus by applying two tests to sense both the fluorescent light and the reflected light from a bank note exposed to ultraviolet radiation, a bank note can be declared genuine or counterfeit with great certainty.

Figure 1 shows apparatus for irradiating a bank note with light and then measuring the amount of fluorescent light and reflected light.

As shown the apparatus includes a generally rectangular container 100 having a window 102 against which a bank note to be sensed can be placed. Within the container 100 there is provided an elongate light source 104 for producing light in the 365 nm region and directing it through the window 102. Also within the container are two photo diodes 104 and 106 spaced apart from one another but angularly inclined so that their optical axes intersect generally at the outer surface of the window 102. Each photo-diode 104 and 106 is mounted on the floor

of a respective tubular opaque housing 108 and 110. The inner walls of the housing are lined with reflective material to increase the sensitivity of the photo-diodes. A 365 nm band pass optical filter 112 covers the housing 108 and a 450 nm band pass optical filter covers the housing 110.

The lamp 104 is surrounded on three sides by reflective material 116 for example aluminium foil which reflects light generally in the direction of the window 102 to concentrate the light at the window.

Preferably the reflective material is so positioned around the light source that the optical plane of the light directed at the window, makes the same angle with the window as do the optical axes of the photo detectors in a manner to ensure that the photo-detectors receive the maximum fluorescent and maximum reflected light from any bank note placed on the window 102.

The window 102 is provided by a glass plate which reflects some of the light received from the source 104 back to the photo-diode 104. The light is principally reflected back from the glass-air boundary of the plate and typically is around 8% of the light directed at the glass plate.

When a genuine bank note is placed on the window the amount of reflected light at 365 nm is usually fairly small and so typically the amount of reflected light will increase from 8% to a value in the range of from 12 to 18%. Thus it will be seen that the light reflected from the plate when no bank note is present can be used as a reference level to compare the degree of reflection with when a bank note is present.

Thus any diminution in light output from the lamp due to ageing or any other defect is automatically compensated. Other errors are also eliminated because the light paths and components used to determine the reference

level are the same as the light paths and components used to effect a measurement.

In the case of fluorescence the amount of fluorescent light emitted by a counterfeit bank note is generally several orders higher than the amount of light emitted by a genuine bank note and so any degradation of the light source 104 makes little or no difference to the detection of fluorescent light.

An electronic processor (not shown but which will be described in more detail hereinafter) monitors the light received by both photocells with the lamp 104 switched on. In the absence of a bank note on a window the photocell 104 will provide a steady state output. As soon as a bank note is placed on the window the output 104 from the photocell will rise and a trigger signal is then generated to activate two measurement circuits for measuring the outputs of the two photocells 104 and 106.

The measurement circuits provide readings which can be displayed by a display device 126, and a decision circuit will, in response to the readings, activate one of two optical indicators 122 and 124 respectively indicating that the bank note is genuine or counterfeit.

A printer (not shown) may be provided to record the values displayed by the display device 126.

It will thus be seen that the apparatus is automatically activated by the placement of a bank note on the window to determine whether the bank note is genuine or counterfeit.

The block diagram of Figure 4 shows the processor in more detail. Each photocell 104 and 106 feeds a respective trigger circuit 130 and 132 for detecting a rapid change in signal for example as a result of a bank note being placed on the window. Either or both trigger circuits 130 and 132 feed a signal to an actuator 134 which actuates two measurement circuits 136 and 138

(for example by supplying power to them or deactivating inhibitors which inhibit their operation). A delay circuit 140 deactuates the measurement circuits 136 and 138 after a short measurement period. A first comparator 142 compares the output of the photocell 104 with a reference value stored in a store 144 and if the detected value exceeds the reference value, an output is generated which is fed simultaneously to the gates 146 and 148. The signal stored in the store 144 is derived from the photocell 104 during the quiescent state of the apparatus. The output of the photocell 104 is amplified by an amplifier 150 by a factor of between 25% and 50% and stored in the store 144. As soon as the actuator 140 is triggered, the amplifier 150 is inhibited so that the store 144 only stores the quiescent value of reflected light. A comparator 152 compares the output of the measurement circuit 138 with a reference value 154 and when the reference value is exceeded generates an output signal which is fed to the two gates 146 and 148.

The gate 146 responds when a genuine note is detected to energise the indicator 122. Similarly the gate 148 responds to energise the indicator 124 when a counterfeit note is detected. The actual values at the outputs of the two measured circuits 136 and 138 are fed to the display 126 for display thereby.

It will be appreciated that the value of the reference signals stored in the stores 144 and 154 can be adjusted as required.

Because of the possible effects of ambient light on the photocells 104 and 106, the apparatus is advantageously shielded by a cover which provides a slot through which a bank note can be inserted onto the window.

Instead the light source can be modulated at a selected frequency and the outputs of the photo diodes demodulated at the same frequency to eliminate the effects

of ambient light.

If it is required to make more precise measurement of the fluorescence signal then it can be normalised to the reference level in the same way as the reflectance signal.

To a near approximation the following relationship applies:

$$rs=(Ps/Pr)^{*}r_g/(1-r_g)^2$$

where Ps is the reflected portion of the irradiating signal from the specimen, Pr is similarly that portion returned from the glass plate to be used as a reference, and $r_g$ is the coefficient of reflectance from the glass plate. It will be noted that the effect of variation in $r_g$ is negligible if small and significant if $r_g$ is allowed to become large. Also that the relationship is inherently non linear and has been simplified to a first approximation. More precise normalisation could be carried out if required.

It has been observed that UV reflection from a bank note varies with the degree of soiling. It may be possible to measure the degree of soiling and to compensate by adjusting the reference values stored accordingly.

The apparatus shown in Figure 5 measures both fluorescent light and reflected light using a single monitor to determine whether a bank note is counterfeit or genuine.

The apparatus comprises an ultraviolet (UV) lamp 2 which is preferably mounted in a hand-held scanning unit. The UV lamp 2 is arranged to emit radiation at a frequency which is known to cause bleached paper to fluoresce.

A detector 3 is arranged to receive both fluorescent and reflected radiation from a bank note 1 but not directly from UV lamp 2 without being reflected. The

monitor may be a photo-diode or phototransistor, for example, sensitive to the appropriate light frequency or frequencies. In particular the monitor should be sensitive to fluorescent light in the 400-500 nm range and to reflected ultraviolet light in the 300-400 nm range so as to be sensitive to counterfeit notes of bleached paper which fluoresce or counterfeit notes which don't fluoresce but because they are counterfeit they often have a higher reflectance to ultraviolet light than genuine notes. An electrical signal is applied from monitor 3 to one input of a comparator 4.

A second detector or monitor 5 is arranged to receive UV radiation directly from lamp 2. The signal from this is first amplified by an amplifier 6 and applied to a resistor 7 the other end of which is earthed. Thus, the voltage across the resistor 7 is proportional to the intensity of the radiation emitted by the lamp. Resistor 7 forms part of a potentiometer, the slider connection of which itself is applied as a second input to comparator 4. The slider can be set to provide a threshold value representing a predetermined proportion of the voltage which is proportional to the UV intensity.

The comparator 4 is arranged to output a signal if the signal received by the monitor 3 is greater than or equal to the set detection threshold. When the threshold is reached it means that a certain proportion of the light impinging upon note 1 has been reflected or re-emitted as fluorescence and therefore it is assumed that the note is counterfeit.

The signal from the comparator 4 is applied through a low pass filter (for example an RC filter 8,9 as shown in Figure 5) to a timer 10. This timer produces a pulse of, for example, approximately one second which actuates a buzzer 11 and a visual alarm in the form of an LED 12. In the example shown buzzer 11 and LED 12 are

mounted in parallel between an output line from timer 10 and ground. Other types of alarm, whether audible or visual or both can be used in addition or as an alternative to those shown. The output pulse from timer 10 may also be applied to a line driver 13 which is adapted to provide a suitable signal for application to a management system. This management system may be used to provide a warning to a remote control position, such as a manager's or security office in a shop for example, that a counterfeit note has been identified. Thus, as an alternative or in addition to the warnings at the point of sale (ie the till) management or security is discretely informed. The line driver may, in one example, provide TTL signals.

It is useful to be able to monitor the output of the lamp directly so that lamp degradation can be noted and thus the lamp replaced in good time. This is achieved in the example shown in Figure 6 by applying the output from amplifier 6 to a first input of a second comparator 14. The other input of comparator 14 is taken from a potentiometer 15 which is used to set a low threshold value for the voltage monitored by lamp monitor 5 and which is therefore proportional to the UV intensity of lamp 2. If the signal from amplifier 6 is less than this low threshold value then a signal is output from comparator 14 to a warning means such as a second LED 16 forming a lamp level low indicator. When this LED lights then the operator is warned to replace the lamp or one of its components.

The apparatus is most preferably configured as a hand-held scanning unit and one, non-limiting example of a suitable housing in which the apparatus may be mounted is shown in Figures 6 to 8. The unit comprises a head 17 in which the UV lamp 2 is mounted to illuminate an object placed underneath the head. A handle 18 is preferably

shaped with a series of ridges for example to facilitate a good hand grip. Power for the apparatus is provided through a mains lead 19 which can be from a mains supply, from an adjacent till or EPOS unit, or by other means. It may alternatively be possible for the apparatus to be powered by batteries, which may be rechargeable batteries, for true portability. A basic on/off switch 20 is provided which enables lamp 2 to be illuminated and therefore the detection apparatus to function only when the switch is depressed by a thumb for example when the unit is being held. If this configuration is adopted then the unit is arranged to operate only in the scan position. In one embodiment, the signal to a remote control or monitoring station, such as a security office, may be transmitted by mains-born signalling. This may be achieved by applying pulses of known frequency onto the mains. If different frequencies are applied by different units then an operator at the remote position, when receiving a signal indicating a counterfeit note, will know which scanning unit has identified that note.

The unit may be temporarily mounted in position, eg by a suitable bracket mounting, when in use and/or when 'dormant'. The portable and adaptable nature of the unit enables great versatility of use in different environments and situations and with different attachments thereto.

It should be noted that the detection circuitry is effectively only operated when the ON/OFF switch is used to actuate the lamp, thereby minimising power consumption and reducing false readings from objects other than those desired to be tested.

An alternative hand-held scanning unit in the form of a wand is shown in Figures 9 and 10. As shown, the wand has a cylindrical housing 58 having a switch 60 on one side and an ultraviolet lamp 62 on the opposite side. A sensor 64 is located adjacent the lamp 62. The

unit operates in a similar manner to the unit of Figures 6 to 8.

The counterfeit objects may be other than bank notes and could be any object, the authenticity of which relies to some extent on the type of paper or other material it is formed from or printed on. In some examples the genuine article may glow under UV light, in which case the apparatus can be suitably modified, eg by reversing the input connections to comparator 4 so that a signal less than a threshold level actuates an alarm.

CLAIMS

1. Apparatus for detecting counterfeit objects comprising means for illuminating the object with light within a first wavelength band, a detector for detecting reflected light from said object having a first wavelength within said first wavelength band and for detecting light having a second wavelength within a second wavelength band different from said first wavelength band, said second wavelength band including wavelengths at which counterfeit objects may fluoresce when exposed to light in said first wavelength band, comparison means for comparing the output of the detector with at least one reference level and decision means for deciding, based on said comparison whether said object is counterfeit or not and providing an appropriate indication.

2. Apparatus according to Claim 1 wherein said first wavelength band width is the ultraviolet light wavelength band width and said second wavelength band width is 400 to 500 nm.

3. Apparatus according to Claim 1 or to Claim 2 wherein said detector comprises first and second photocells each positioned to receive light from a said object respectively through a first optical filter only passing light in said first wavelength band and through a second optical filter only passing light in said second wavelength band.

4. Apparatus according to any one of Claims 1 to 3 including a glass plate for supporting a said object on one side thereof with the illumination means and the detection means being located on the other side thereof and directed at the object through said glass plate.

5. Apparatus according to Claim 4 as dependant upon Claim 3 including reference means for storing a first reference level which is a function of the light reflected

by the glass plate in the absence of an object thereon and received by the first photocell.

6. Apparatus according to Claim 4 or Claim 5 as dependant upon Claim 3 wherein the optical axes of the photocells and the light source converge upon that surface of the glass plate which is arranged to support a said object.

7. Apparatus according to any preceding claim including shielding means for shielding said detector from ambient light.

8. Apparatus according to Claim 3 including means responsive to any rapid surge in received light to actuate said comparison means to effect a comparison.

9. Apparatus according to any preceding claim including measurement means responsive to the detector to provide a record of the magnitude of the received signals having wavelengths in said first and second bands.

10. Apparatus according to any preceding claim wherein said decision means comprises two indicators, one providing a first indication when the object is counterfeit and the other providing a second indication when the object is genuine.

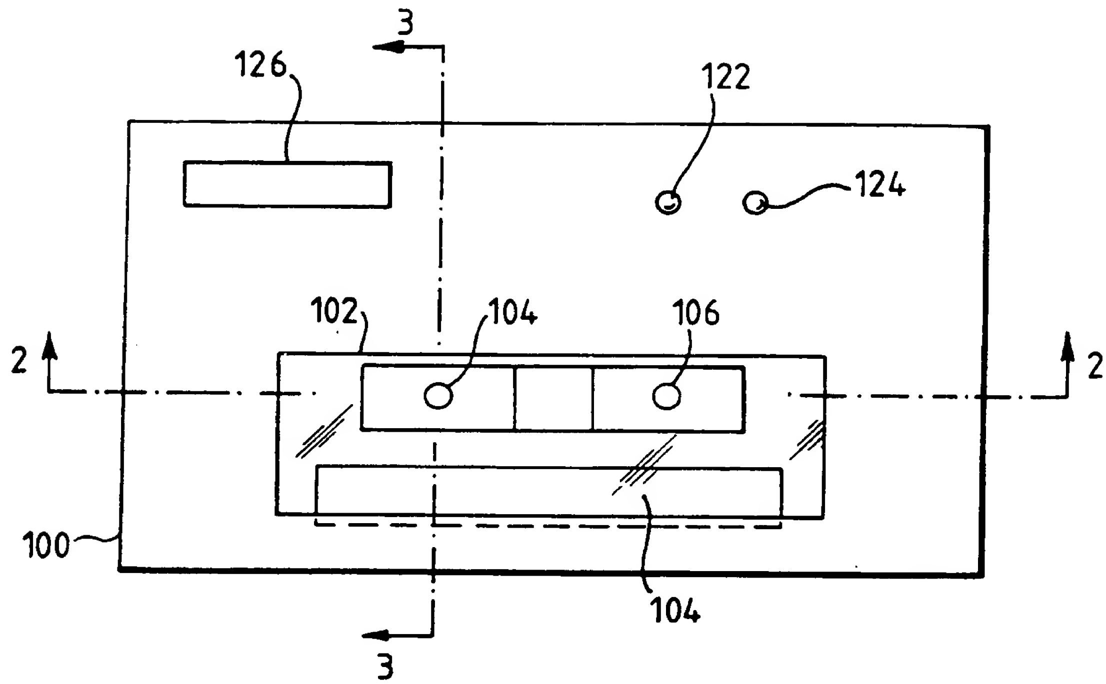


Fig.1.

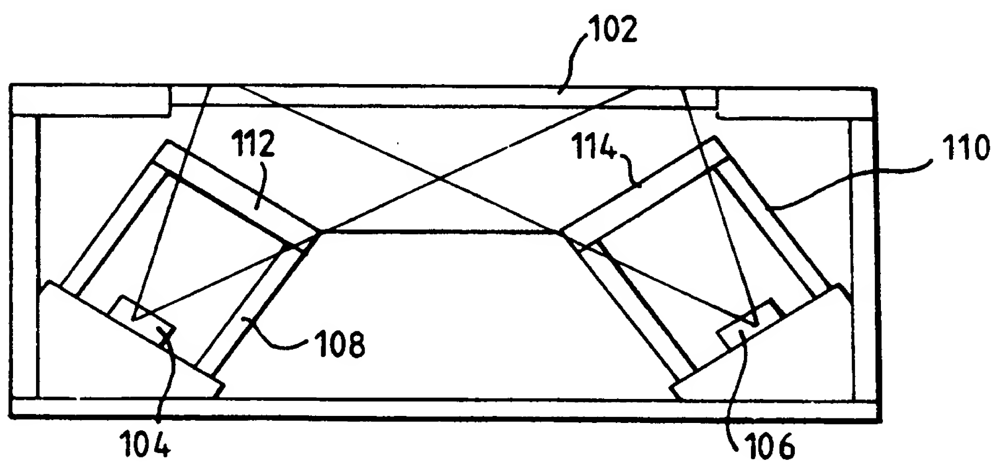


Fig.2.

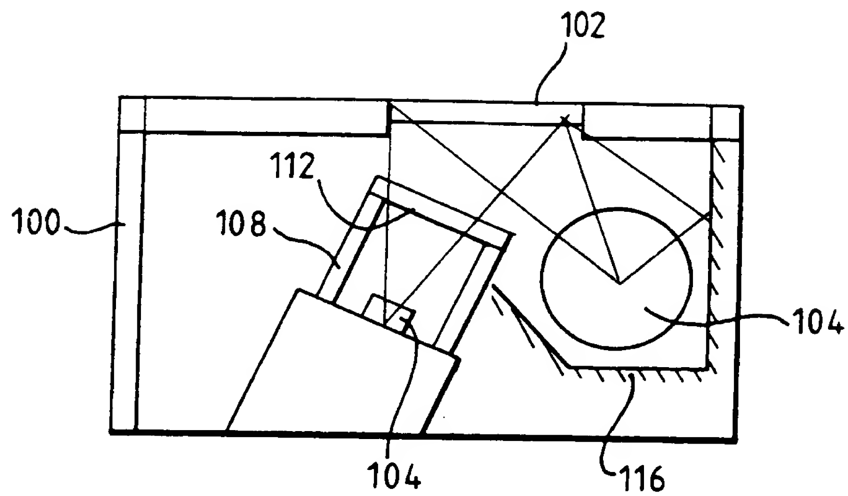
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Fig.3.

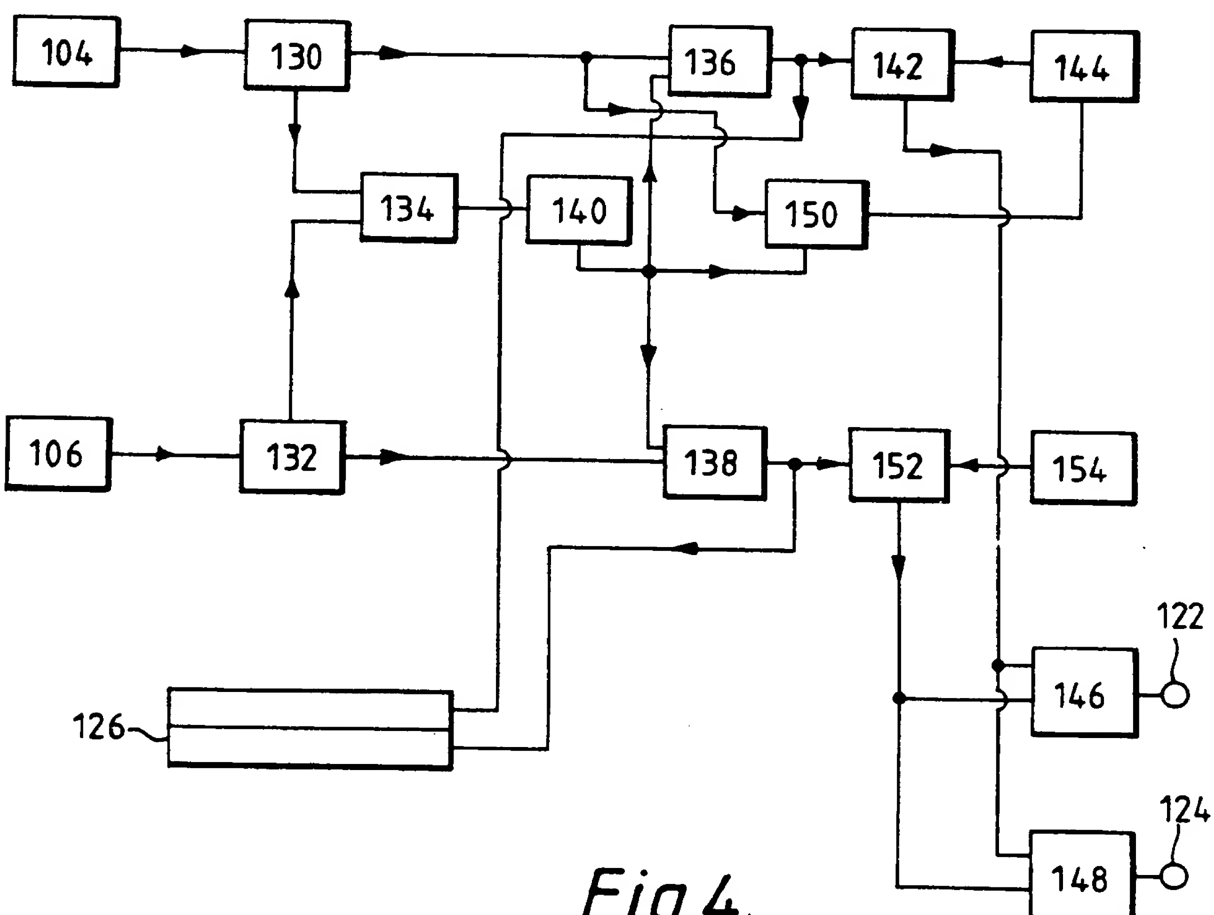
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Fig.4.

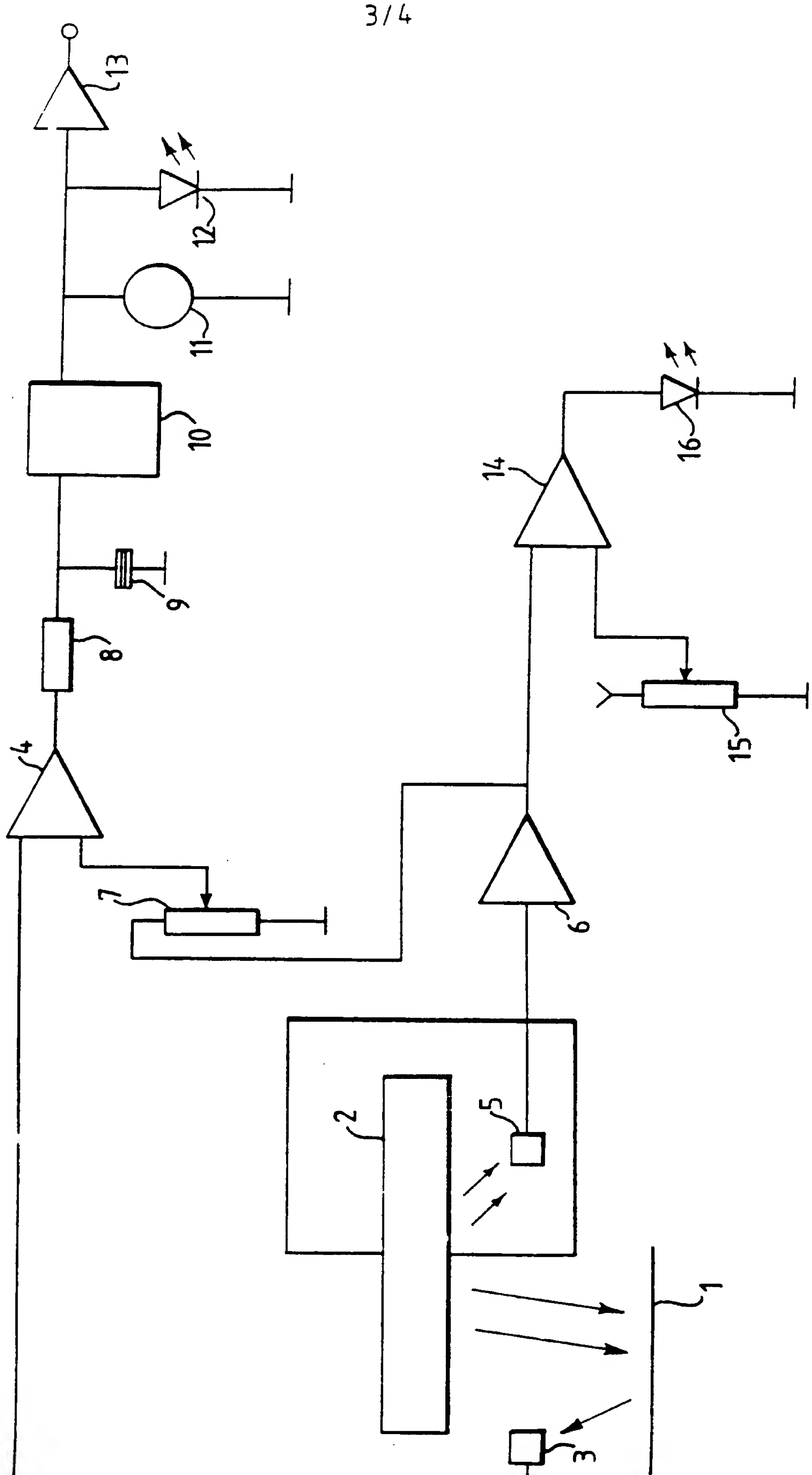


Fig.5.

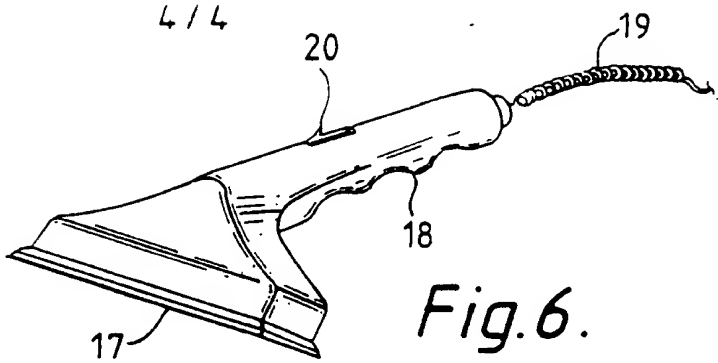


Fig.6.

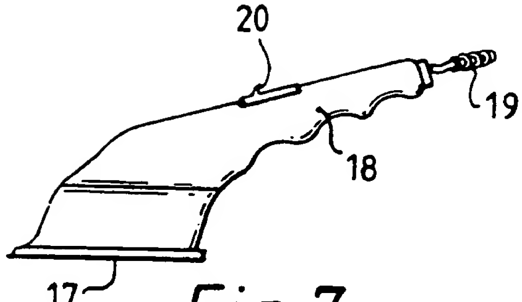


Fig.7.

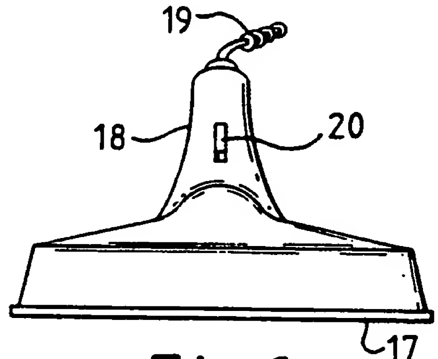


Fig.8.

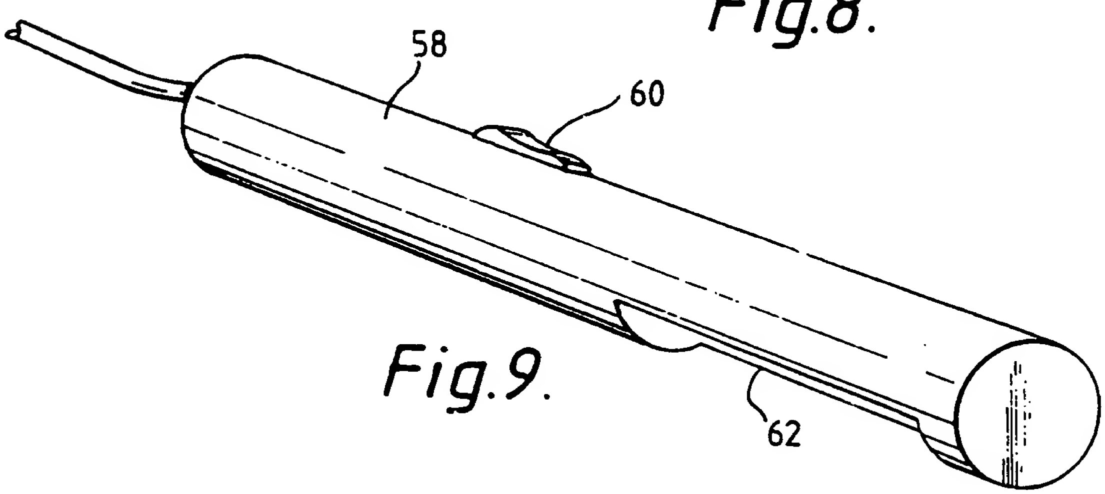


Fig.9.

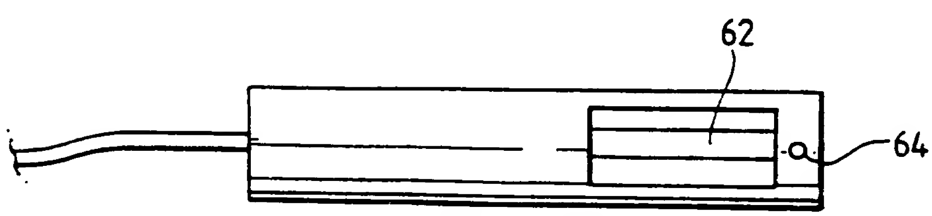


Fig.10.

# INTERNATIONAL SEARCH REPORT

Inte    nal Application No
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**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 5 G07D7/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| Y | see abstract<br>see page 1, line 15 - page 2, line 5<br>see page 2, line 11 - line 16<br>--- | 3,4,9 |
| Y | US,A,4 146 792 (STENZEL) 27 March 1979 | 3,4,9 |
| A | see abstract<br>see column 2, line 46 - column 3, line 12<br>see claim 1<br>--- | 5,6 |
| A | WO,A,89 00319 (GLOBAL SECURITY) 12 January 1989<br>see abstract<br>see page 3, line 12 - page 4, line 4<br>see claim 1<br>---<br>-/-- | 1-3,10 |

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 22 April 1994 | 11.05.94 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
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# INTERNATIONAL SEARCH REPORT

Inte  nal Application No
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| C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT | | |
|---|---|---|
| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| A | EP,A,0 257 749 (DE LA RUE SYSTEMS) 2 March 1988<br>see abstract<br>----- | 1 |

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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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Information on patent family members

International Application No
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